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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Maximum Rates of Precipitation at Boston for Various Frequencies of Occurrence." Harrison P. Eddy.

Memoirs of Deceased Members.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, January 28, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the Senior Vice-President, Leonard C. Wason.

There were 139 members and visitors present.

The reading of the record of the last meeting was dispensed with and it was approved as printed in the January JOURNAL.

The Secretary reported for the Board of Government the election of the following candidates to membership in the grades named:

Members: George Budd, Jr., George C. Danforth, Howard W. Green, Henry C. Sheils, Miner R. Stackpole.

Junior: William W. Hall, Jr.

The Secretary submitted the following reports of committees appointed to prepare memoirs of deceased members, and by vote the memoirs were ordered printed in the JOURNAL of the Society: Memoir of Edmund Grover, prepared by Messrs. R. A. Hale and A. L. Plimpton; and memoir of Irving S. Wood, prepared by Messrs. W. W. Bullock and J. A. McKenna.

Mr. F. O. Whitney, for the Board of Government, offered the following vote:

"*Voted:* That in view of a probable deficit in the current expenses, a sum not exceeding fifteen hundred (1 500) dollars be appropriated from the income of the Permanent Fund to make good such deficiency."

Past-President Charles R. Gow offered the following amendment:

"That the entire income of the Permanent Fund for the current year be appropriated and placed at the disposal of the Board of Government for use in payment of the expenses of the Society so far as in their judgment it is deemed advisable."

Mr. Whitney accepted the amendment and in its amended form the vote was adopted unanimously.

This vote, in accordance with the By-Laws, will come before the Society a second time at the next regular meeting of the Society.

The chairman then introduced the speaker of the evening, Mr. A. N. Johnson, consulting highway engineer, Portland Cement Association of Chicago, who read a paper entitled "Construction of Concrete Roads." The paper was illustrated with lantern slides.

A discussion followed the reading of the paper, in which Messrs. A. W. Dean, E. S. Larned, L. E. Moore, F. B. Walker, and others took part.

On motion of Past-President Gow, the thanks of the Society were extended to Mr. Johnson by a unanimous rising vote.

Adjourned.

S. E. TINKHAM, *Secretary*.

APPLICATIONS FOR MEMBERSHIP.

[February 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

MORTENSON, ERNEST DAWSON, Bedford, Mass. (Age 24, b. East Boston, Mass.) Graduate of Concord (Mass.) High School in 1913, and of Tufts College in 1917, with degree of B.S. in civil engineering. From June to September, 1916, chainman, and from May to September, 1917, head of party in Terminal Division, Engineer's Office, B. & M. R. R.; from September, 1917, to June, 1919, structural draftsman, B. & M. R. R., engaged in general drafting, computation and design of highway bridges and computing stresses of railroad bridges; and from July, 1919, to date, structural draftsman with Aberthaw Construction Co., at present designer of reinforced concrete buildings. Refers to S. P. Coffin, H. A. Gray, Pusey Jones, A. W. Knowlton, J. B. Mailey, E. H. Rockwell, J. J. Rourke and F. B. Sanborn.

ROY, JOSEPH ERNEST, Springfield, Mass. (Age 26, b. Springfield, Mass.) Graduate Worcester Polytechnic Institute, B.S. degree in civil engineering, 1915. From 1915 to 1918, with J. R. Roy & Sons Co., building contractors, as superintendent of construction, 1918; attended Mass. Inst. of Technology, completing intensive course in naval architecture, and 1918 and 1919, lieutenant (j. g.) Construction Corps, U. S. Navy. Elected a junior March 5, 1915, and now desires to be transferred to grade of member. Refers to C. M. Allen, A. W. French, H. C. Ives, A. J. Knight and A. W. Knowlton.

TURNER, HOWARD MOORE, Cambridge, Mass. (Age 35, b. Wareham, Mass.) Graduate of Harvard University, A.B. 1906 and S.B. in civil engi-

neering 1907. Rodman on construction at Harvard Stadium, summer of 1903; from June, 1907, to January, 1910, with Turner Construction Co., New York City, as instrumentman, in estimating department, and assistant superintendent on construction work; from January, 1910, to April, 1911, supervising engineer, Easthampton Gas Co., in charge of construction of 1 500-kw. steam station and nine miles of high-tension electrical transmission line; from April, 1911, to April, 1912, investigation and report work for Turners Falls Power and Electric Co., for their hydro-electric plant at Turners Falls; from April, 1912, to June, 1917, resident and later hydraulic engineer in charge of construction and detail plans for 60 000 h.p. development at Turners Falls; from June, 1917, to August, 1918, assistant to the president of the Turners Falls Power and Electric Co., Boston, in connection with future development at Turners Falls, steam station at Chicopee, high-tension line from Providence to Fall River and miscellaneous engineering work. August, 1918, commissioned first lieutenant engineer in U. S. Army; after two months in the E. O. T. C. at Camp Humphreys, assigned to 606th Engineers at that camp. From January 1, 1919, to date, in private practice with office in Boston. Lectures on Water Power Engineering at Harvard Engineering School. Refers to R. E. Barrett, H. J. Hughes, L. J. Johnson, H. A. Moody, J. R. Nichols and A. T. Safford.

LIST OF MEMBERS.

ADDITIONS.

DANFORTH, GEORGE C.....	27 Weston St., Augusta, Me.
HALL, WILLIAM W., Jr.....	99 Salisbury St., Worcester, Mass.
STACKPOLE, MINER R.....	104 Queensberry St., Boston, Mass.

CHANGES OF ADDRESS.

ARONSON, MARK.....	65 Bainbridge St., Roxbury, Mass.
BARRETT, R. E.....	Holyoke Water Power Co., Holyoke, Mass.
BIGELOW, L. W.....	1022 Main St., Worcester, Mass.
BOAS, BENJAMIN.....	224 Main St., Norwalk, Conn.
FALKENBERG, JOHN J.....	3 Dartmouth Ave., East Dedham, Mass.
HARTWELL, HERBERT C.....	108 Massachusetts Ave., Boston 17, Mass.
LAKE, HARRY E.....	40 Temple St., Reading, Mass.
LONG, WILLIAM J.....	

	Apt. 22, New Berne, 12th and Mass. Ave., Washington, D. C.
MCCORKINDALE, R. I.....	130 Oakland Ave., Methuen, Mass.
MORRISON, HARRY J.....	P. O. Box 503, Gainesville, Fla.
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PROCEEDINGS.

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SUMNER, MERTON R.....	Care Fuller Industrial Engineering Corporation, Room 1710, Fuller Bldg., New York, N. Y.
SYLVIA, MANUEL H.....	29 Broadway, New York, N. Y.
TOZZER, ARTHUR C.....	178 Tremont St., Boston, Mass.

DEATHS.

FULLER, FRANK L.....	January 30, 1920.
PRATT, R. WINTHROP.....	February 2, 1920.

LIBRARY NOTES.

BOOK REVIEW.

"THE TURNPIKES OF NEW ENGLAND: Evolution of the same through England, Virginia and Maryland," by Frederick J. Wood., member American Society Civil Engineers, member Boston Society of Civil Engineers, member New England Historic-Genealogical Society, lately major of Engineers, U. S. Army. Illustrated, Marshall Jones Company, Boston. Cloth, $7\frac{1}{2} \times 11$ ins.; pp. XVII + 461. \$10.00.

REVIEWED BY FRANK O. WHITNEY.

Major Frederic J. Wood, the author of the work with this title, gives to the public, as the result of ten years' study, a volume which is exhaustive, authoritative and human, and should appeal to the engineer, the historian and the general reader.

The turnpike as an institution was an important factor in the country's development during the first half of the nineteenth century.

At the close of the Revolutionary War, communication between the states forming the permanent union was primitive and difficult. As agents in laying the foundation for the amalgamation of diverse interests into a concrete body politic, the turnpike and the stage coach played a very important part, and can be compared with the importance economically of the great railroad extensions after the Civil War.

The incorporation of turnpike companies in New England

began in 1792 and continued for a century. In Massachusetts alone one hundred and eighteen charters were granted, but only sixty resulted in road building. The total investment in turn-pikes in Massachusetts was about \$2 380 000.

It is of special interest that the railroads have closely followed the lines of the turnpikes.

While the usefulness of the turnpikes is without question, financially they were losing ventures, there having been then as now a popular prejudice against public-service corporations.

Major Wood gives an historical sketch of each road, facts in connection with the construction and operation, together with over three hundred illustrations from photographs taken by himself. Several maps show the connection of the various roads into a comprehensive system reaching out into every important section of New England.

This is believed to be the first comprehensive history of American turnpikes, and, considering the difficulties of getting at the facts, it may be fairly classed among the remarkable books of the past twenty-five years.

Major Wood is a member of the Boston Society of Civil Engineers and the American Society of Civil Engineers. He was a major of engineering during the late World War.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Boundary between United States and Canada. Joint report of Commissioners, 1918.

Chief of Engineers, U.S.A. Annual report for 1919. 3 parts.

Financial Statistics of Cities having a Population of over 30 000, 1918.

Interstate Commerce Commission. Thirty-third annual report. 1919.

Superintendent Coast and Geodetic Survey. Annual report for 1919.

U. S. Housing Corporation, Report of. Vol. 2. Houses, Site Planning and Utilities. 1919.

State Reports.

Massachusetts. Annual report of Homestead Commission for 1918.

New Jersey. Annual report of Department of Conservation and Development for 1918.

City and Town Reports.

Boston, Mass. Annual report, City Planning Board, 1919.

Medford, Mass. Annual report of Water and Sewer Commissioners for 1918.

New Bedford, Mass. Annual report of City Engineer for 1918.

Philadelphia, Pa. Annual report of Bureau of Surveys for 1918.

Providence, R. I. Annual report of City Engineer for 1918.

Miscellaneous.

American Railway Master Mechanics Association, Proceedings for 1917-1918.

American Society of Mechanical Engineers, Transactions for 1918.

Design of Steel Bridges. F. C. Kunz. 1915.

Graphical and Mechanical Computation. Joseph Lipka. 1918.

Industrial Building Book. C. F. Dingman. 1919.

Industrial Plants. C. T. Main. 1917.

Irrigation Engineering. A. P. Davis and H. M. Wilson. 1919.

Mechanical Equipment of Buildings. Vol. 1. Heating and Ventilating. Harding and Willard. 1917.

Meter Rates for Water Works. Allen Hazen. 1918.

The Turnpikes of New England. F. J. Wood. Gift of author. 1919.

Water Rights Determination. J. M. Whitman. 1918.

LIBRARY COMMITTEE.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

MAXIMUM RATES OF PRECIPITATION AT BOSTON FOR VARIOUS FREQUENCIES OF OCCURRENCE.

BY HARRISON P. EDDY,* PAST PRESIDENT BOSTON SOCIETY OF CIVIL
ENGINEERS.

It has long been recognized that maximum rates of precipitation which are likely to prevail for given periods of time are of prime importance in the design of combined sewers and storm-water drains. The so-called rational method of design can only be applied by making use of figures for maximum rates of precipitation. It is therefore of great importance to have trustworthy data relative to the occurrence of excessive storms, giving the rates which have prevailed for various durations and the frequency at which such storms have recurred at any particular place, in order to make intelligent application of the rational method. Such a record is available at Boston for Chestnut Hill Reservoir, since 1879, and for the Weather Bureau station since 1891. The records have been worked up and the intensity and frequency curves computed for the periods ending with 1916, and therefore covering thirty-eight years at Chestnut Hill and twenty-six years for the Weather Bureau gage.

SOURCES OF INFORMATION AND PREVIOUS STUDIES.

The original record sheets of the Chestnut Hill Reservoir gage have kindly been placed at our disposal by Mr. William E.

* Of Metcalf & Eddy, 14 Beacon Street, Boston.

NOTE. This paper will not be presented at a regular meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, before April 10, 1920, for publication in a subsequent issue of the JOURNAL.

Foss, chief engineer of the Metropolitan Water Works, and the storms have been analyzed and tabulated by us.

The data obtained from the United States Weather Bureau gage at Boston are published in the annual reports of the chief of the Weather Bureau, beginning with that for the year 1895-1896, and in the Monthly Weather Review for the period since the publication of the last annual report.

Mr. E. S. Dorr, engineer of the Sewer Service of the City of Boston, studied the first fourteen years' record of the Chestnut Hill gage, and in the report of the Boston Street Department for 1892 published the result of his study and the mathematical formula for a rainfall curve to be used for sewer design in Boston. Mr. Charles W. Sherman, in a paper before the American Society of Civil Engineers, entitled "Maximum Rates of Rainfall at Boston," published in the Transactions of that Society, Volume 54, page 173, derived two curves, one for the maximum storms observed up to 1904, the other a suggested curve to be used in design of storm-water drains. Metcalf & Eddy's "American Sewerage Practice," Volume I, contains a further discussion of the data in that paper, with additional curves based upon the information therein — that is, for twenty-six years records of the Chestnut Hill gage. Emil Kuichling and Henry F. Bryant in a report upon the Adequacy of the Present Sewer System of the Back Bay District of Boston, made in 1909, discussed the data presented in Mr. Sherman's paper, together with the five additional years' records of the Chestnut Hill gage then available and the Weather Bureau records up to the same year, and offered another curve for use in design.

The several formulas suggested for representing rainfall curves are as follows (where i represents the intensity of precipitation in inches per hour, and t the duration in minutes):

$$i = \frac{150}{t+30} \text{ (Dorr, 1892).}$$

$$\text{Maximum } i = \frac{38.64}{t^{0.687}}; i = \frac{25.12}{t^{0.687}} \text{ (Sherman, 1905).}$$

$$i = \frac{120}{t+20} \text{ (Kuichling, 1909).}$$

$$i = \frac{15.5}{t^{0.5}} \text{ (Metcalf & Eddy, 1914).}$$

None of these equations was offered to represent rainfall for any definite degree of frequency. The subject of frequency is not discussed in any of the preceding articles, except in Metcalf & Eddy's "American Sewerage Practice," where curves of relative frequency are given, based upon the twenty-six years' record of the Chestnut Hill rain gage, but mathematical formulas were not suggested for any of these curves.

Intensity-frequency curves for Boston were prepared for United States Housing Corporation by Mr. E. P. Burke, under the direction of Prof. F. E. Turneure, and published in *Engineering Contracting* for October 9, 1918, page 340.

SETTING AND EXPOSURE OF AUTOMATIC RAIN GAGE AT CHESTNUT HILL RESERVOIR.

The automatic gage designed by Mr. Desmond FitzGerald, was described by him in *Engineering News* of May 31, 1884. In this description he notes that the collecting rim used was 14.85 ins. in diameter, — the same size as the standard water-works rain gage in which one ounce of rain collected represents 0.01 in. This rim was originally set "three feet above the roof of a small building at a height of 25 ft. above the ground, and bracketed out from the end of the building so as to give a fair exposure." In his paper entitled "Maximum Rates of Rainfall," in Transactions, Am. Soc. C. E., August, 1889, Mr. FitzGerald noted that in utilizing the recording gage records proper correction was applied for the elevated gage, due to its height above the ground:

"It is already a well-established fact that the higher we rise above the ground the less rain we can collect unless special construction is resorted to. . . . The receiver of the self-recording gage being placed on the roof of a small building about 25 ft. above the ground it becomes necessary to make the proper correction for altitude, which is done by taking the ratio of each storm in the upper gage to that in the ground gage and applying this percentage to any particular portion of the storm."

Later, the setting of this gage was changed, and in 1895 it was slightly above the ridge of the carpenter-shop roof, nearly over the center of the building, instead of being bracketed out



FIG. 1. CARPENTER SHOP ON WHICH RECORDING RAIN GAGE IS LOCATED, CHESTNUT HILL RESERVOIR.



FIG. 2. RAIN GAGES ON ROOF OF POST-OFFICE BUILDING, BOSTON.

from the end as described above. It was about 25 ft. above the ground as previously. There was a platform around the gage, probably 4 or 5 ft. square, evidently built for the purpose of reducing as much as possible the effect of the pitch roof upon wind currents. (Fig. 1.)

The building on which the gage was located was in 1895 in the approximate location indicated upon the sketch (Plate I), and it is understood that this is the position in which it had been from the time the gage was established.

The distance from the ground gage was therefore about 450 ft. In 1898, when the low-service pumping station was constructed, it was necessary to move the carpenter shop to its present location, as shown upon the plan. The distance from the ground gage to the recording gage is now about 800 ft.

SETTING AND EXPOSURE OF RAIN GAGE AT BOSTON OFFICE, U. S. WEATHER BUREAU.

The collector of the Marvin rain gage in use at this station is located on top of the westerly tower of the Post-Office Building. (Fig. 2.) This tower is about at the middle of the Devonshire Street side and 30 to 35 ft. lower than the easterly tower. The top of the tower is nearly flat and is surrounded by an iron picket fence. The space inside the fence is 60 ft. square, and the cornice outside the fence is approximately $1\frac{1}{2}$ ft. wide. In the center of the roof is a wooden box upon which two rain gages are mounted, — one an ordinary non-registering gage, the other the collector of the Marvin gage from which electric wires lead to the recording instrument in the Weather Bureau office. The top of the Marvin gage collector is $5\frac{1}{2}$ ft. above the roof, and that of the other gage is about 6 ins. higher.

There are three or four large iron ventilators projecting above the roof to a height of about 4 ft., and also at the westerly side the covered exit from the stairs. The picket fence is $3\frac{1}{2}$ ft. high, with spikes at intervals, projecting 18 ins. higher.

The collector of the Marvin gage is surrounded by a screen or outer tube about $1\frac{1}{2}$ or 2 ins. outside the collector proper. Apparently even this small screen has been effective in overcoming the effect of wind currents and eddies around the gage.

Records of Chestnut Hill Reservoir Rain Gage. — The maximum intensities of rainfall for various periods of time at Chestnut Hill are given in Table 1. These intensities were computed from the original records. In preparing this table, all storms which appeared from an inspection of the charts to be of importance were included. In general it may be said that all storms of intensities equal to or greater than the following rates for specified periods were included.

5 min.....	2.5 ins. per hour
10 min.....	2.0 ins. per hour
15 min.....	1.5 ins. per hour
20 min.....	1.5 ins. per hour
30 min.....	1.0 ins. per hour
45 min.....	0.3 ins. per hour
60-180 min.	0.2 ins. per hour

Records from both gages were available for 144 storms. A comparison of the records of total precipitation for each entire storm, as obtained from the standard and recording gages, gave the following results:

	Storms.
Automatic gage record higher than standard gage record.....	16
Automatic gage record the same as standard gage record.....	8
Automatic gage record lower than standard gage record.....	<u>120</u>
Total.....	144

The range of the differences for these storms having a higher record by the automatic gage is 0.01 to 0.15 in. For the storms having a lower record by the automatic gage the range is 0.01 to 1.67 ins. There were 9 such storms, having a difference of 0.50 in. or more.

In the preparation of Table 1 it has been assumed that the standard gage gave the correct record and the rates indicated by the automatic gage have been corrected by applying a factor ascertained by comparison of the standard and automatic gage records. This factor was applied uniformly to the rates for all periods, notwithstanding that it was recognized that the correction might more properly be applied to some rates than to others in the same storm. However, no means are available for ascertaining which rates are most in error and what factors to apply to correct the several rates.

SKETCH SHOWING LOCATION OF RAIN GAGES AT CHESTNUT HILL

SCALE IN FEET
0 10 20 30 40 50 100 150

MARCH 31 1919

CHESTNUT HILL RESERVOIR

Effluent Gate House No. 2

St

Beacon

Rain Gages

Shelter for
Meteorological
Instruments

Stable

Low Service
Pumping Station

Approximate former
location of Carpenter Shop

Recording Rain Gage on Roof

Blacksmith Shop

Open
Shed

Pipe Yard

Stiff Leg
Derrick

High Service
Pumping Station

Garage

B. & A. R. R.

PLATE I.
JOURNAL BOSTON SOCIETY
OF CIVIL ENGINEERS.

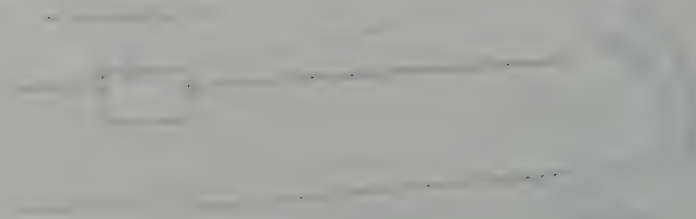
FEBRUARY, 1920.

EDDY ON MAXIMUM RATES OF
PRECIPITATION.

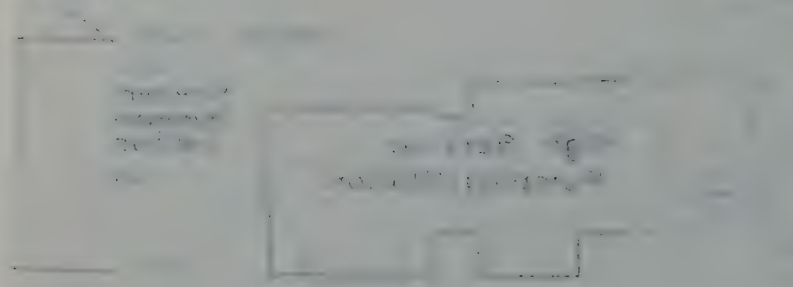
LOCATION OF RAIN GAGES AT
CHESTNUT HILL.

ACORN - 10/15/50

6-7



10/15/50
T.J. Smith



10/15/50

Records of U. S. Weather Bureau Rain Gage. — As noted above, the records of this gage have been published in the annual reports of the chief of the Weather Bureau and in the Monthly Weather Review. The first publication, in the annual report for the year 1895-1896, is in somewhat different form than that employed in the later reports. In this case the precipitation for the maximum 5, 10 and 60 minutes of the storm was given, but not the progressive amounts for five-minute intervals, from the beginning of the excessive rate, which is the form followed in the later reports and in the Monthly Weather Review.

Table 2 contains the data relating to excessive storms at Boston as compiled from these several reports. The Weather Bureau classification includes as "excessive" storms those in which 0.25 in. fell in any five minutes, or 0.80 ins. in any hour. From Table 2 the maximum amounts for 5, 10, 15 minutes, etc., have been picked out, and the rates or intensities corresponding to these periods have been computed. The results are given in Table 3.

Frequency of Excessive Rates of Precipitation. — The intensities of precipitation given in Tables 1 and 3 have been plotted on diagrams showing the years of occurrence and the intensities for 5, 10, 20, 30, 45, 60, 80, 100, 120, 150 and 180 minutes, omitting points showing intensities which were so low that they had no effect in determining curves. These diagrams served as the first step for the construction of frequency curves; for instance, on the 38-year record of the Chestnut Hill gage the highest point for any duration obviously represented an intensity which occurred but once during the period, and therefore had a frequency of thirty-eight years. The second point represented an intensity which was equaled or exceeded twice, and therefore had an average frequency of nineteen years, etc.

As just stated, a frequency curve represents intensities which have not been equaled or exceeded on the average oftener than once in a certain number of years. It should be borne in mind, however, that such a curve may be equaled or exceeded by more than one storm during that period of years; for while on the average but one storm equaling or exceeding the curve will come within the period designated, two such storms on the

TABLE I. — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESTNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.													
	Standard Gage.	Recording Gage.														
			5	10	15	20	25	30	45	60	80	100	120	150	180	
1879																
June 29	1.41	1.07	4.27	3.01	2.11	1.98	1.90	1.74	1.55	1.19	0.91	0.74	0.67	...	...	...
July 16	...	0.72	4.20	3.36	2.56	1.95	1.59	1.32	0.93	0.42	...	...	...	...	...	...
Aug. 16-19	6.23	4.56	2.96	2.55	1.97	1.65	1.38	1.23	0.95	0.88	0.88	0.88	0.84	0.74	0.67	...
1880																
Apr. 16	0.77	0.72	1.29	0.96	0.86	0.71	0.64	0.60	0.43	0.34	0.30	0.28	0.25	...	...	...
July 20-21	1.99	1.73	5.52	4.83	4.14	3.56	3.03	2.72	1.94	1.50	1.23	1.04	0.83	...	...	...
1881																
Jan. 10	2.20	2.20	0.48	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.36	0.36	0.34	0.33	0.33	0.33
Feb. 12	1.55	1.44	0.91	0.71	0.61	0.52	0.47	0.43	0.42	0.36	0.35	0.35	0.35	0.31	0.27	0.27
June 10-11	3.83	3.50	0.65	0.65	0.65	0.62	0.60	0.59	0.55	0.52	0.51	0.51	0.50	0.48	0.45	0.45
July 21	0.48	0.36	4.63	2.71	1.92	...	...	...	...	...	...	...	...	...	...	...
Sept. 2-3	1.79	1.74	2.84	2.48	2.26	1.95	1.68	1.44	1.07	0.81	...	...	...	...	...	...
1882																
June 18	0.57	0.56	1.46	1.10	0.90	0.86	0.78	0.77	0.65	0.54	...	...	...	...	...	...
July 19	0.48	0.43	2.68	2.00	1.60	1.30	...	...	...	...	...	...	...	...	...	...
Sept. 11-12	3.00	2.35	1.38	1.15	0.92	0.81	0.74	0.69	0.51	0.49	0.41	0.41	0.40	0.33	0.34	0.34
Sept. 14	1.13	1.05	3.21	2.38	2.01	1.77	1.59	1.50	1.44	1.11	0.85	0.85	0.80	0.75	0.73	0.73
Sept. 21	1.13	1.10	1.86	1.24	1.03	0.83	0.72	0.62	0.51	0.48	0.42	0.36	0.30	0.25	0.23	0.23
Sept. 22-23	2.55	2.38	1.29	1.16	0.94	0.84	0.74	0.69	0.70	0.67	0.61	0.58	0.60	0.58	0.53	0.53
Sept. 24	0.44	0.41	1.28	1.09	0.94	0.77	0.63	0.54	0.44	0.34	...	...	...	...	...	...
1883																
Mar. 10	0.75	0.74	0.97	0.73	0.61	0.49	0.41	0.36	0.31	0.32	0.26	0.29	0.25	0.21	0.18	0.18
May 31	0.47	0.42	3.50	2.08	1.71	1.31	1.05	0.90	...	...	...	...	...	...	...	...
June 29	0.59	0.56	4.67	2.71	2.02	1.61	1.36	1.18	...	...	...	...	...	...	...	...
Nov. 26-27	1.51	1.39	0.92	0.79	0.61	0.62	0.60	0.52	0.48	0.39	0.34	0.37	0.34	0.30	0.29	0.29

MAXIMUM RATES OF PRECIPITATION AT BOSTON. 55

1884	1.66	1.55	3.59	3.02	2.45	2.19	1.87	1.85	1.51	1.33	1.10	0.88	0.75	0.63	0.54
June 19	2.76	2.56	2.33	1.82	1.39	1.17	1.06	1.00	0.82	0.69	0.59	0.52	0.46	0.41	0.37
June 25-26	1.19	1.14	9.12	4.93	3.41	...	...	...	...	...	...	...	...	...	...
July 18	1.06	1.03	1.24	0.93	0.87	0.80	0.74	0.70	0.69	0.60	0.50	0.43	0.39	0.33	0.34
Aug. 5-6	2.14	1.97	1.18	0.98	0.87	0.85	0.81	0.76	0.74	0.61	0.47	0.42	0.41	0.35	0.39
Aug. 7-8															
1885															
June 28-29	1.26	1.15	1.31	1.24	1.09	1.05	0.97	0.92	0.93	0.86	0.76	0.64	0.54	0.45	0.38
June 29	1.17	1.05	3.33	2.79	2.44	1.97	1.71	1.51	1.13	0.94	0.72	0.62	0.52	0.44	0.38
July 29	0.81	0.76	1.92	1.73	1.41	1.35	1.26	1.11	0.86	0.69	0.55	0.44	0.39	...	...
Aug. 1	1.76	1.61	3.27	2.03	1.75	1.58	1.41	1.37	1.09	1.05	0.97	0.78	0.66	0.59	0.50
Oct. 2-3	1.25	1.18	3.55	2.04	1.48	1.21	1.02	1.02	0.88	0.72	0.56	0.46	0.40	0.33	0.29
1886															
July 15	1.74	1.59	3.27	2.36	1.62	1.24	1.10	1.13	0.95	0.83	0.73	...	...	...	...
1887															
July 10	1.10	0.99	2.39	2.20	1.82	...	...	...	...	...	...	...	...	...	...
July 22	1.16	0.97	1.59	1.37	1.20	1.19	1.10	1.01	0.96	0.83	0.68	0.61	0.55	0.45	0.38
July 23	0.67	0.60	1.34	1.21	0.99	1.01	0.86	0.76	0.64	0.50	0.41	0.33	...	...	...
1888															
May 13	1.32	1.22	1.69	1.31	1.08	1.13	1.11	1.00	0.88	0.69	0.67	0.63	0.59	0.51	0.43
Aug. 6	1.17	1.08	1.17	0.97	0.91	0.84	0.78	0.80	0.75	0.70	0.55	...	...	...	...
Aug. 12-13	1.73	1.60	2.07	1.83	1.73	1.62	1.55	1.51	1.37	1.13	0.89	0.75	0.67	0.57	0.49
Aug. 21-22	3.44	3.23	2.80	2.54	2.55	2.39	2.11	1.96	1.72	1.58	1.36	1.28	1.22	1.10	1.00
Sept. 10	1.35	1.30	1.85	1.42	1.24	1.05	0.94	0.83	0.74	0.70	0.62	0.56	0.53	0.47	0.42
Sept. 17-18	1.94	1.78	1.31	1.31	1.22	1.05	0.99	0.96	0.95	0.93	0.82	0.73	0.65	0.57	0.50
1889															
Apr. 26	1.66	1.31	1.68	1.15	0.91	0.76	0.70	0.67	0.54	0.48	0.44	0.39	0.37	0.39	0.37
May 20-21	3.17	3.19	1.67	1.30	1.35	1.28	1.23	1.15	0.85	0.89	0.69	0.58	0.62	...	...
June 2	1.59	1.55	2.22	1.86	1.52	1.27	1.14	1.03	0.91	0.75	0.69	0.61	0.55	0.45	0.44
June 5	0.47	0.47	2.64	1.62	1.12	...	...	...	...	...	...	...	...	...	...
July 17	0.75	0.68	3.97	3.32	2.16	1.72	...	...	...	...	...	...	...	...	...
Aug. 1	0.51	0.48	2.55	1.34	0.98	0.80	...	...	...	...	...	...	...	...	...
Aug. 14	1.60	1.51	2.55	1.78	1.32	1.02	0.81	0.68	0.47	0.39	0.36	0.30	0.26	0.21	...
Sept. 11	1.35	1.04	2.66	1.56	1.30	1.09	0.87	0.73	0.50	0.47	...	...	...	...	...
Sept. 18	2.23	2.03	1.98	1.52	1.32	1.32	1.19	1.10	0.95	0.83	0.67	0.54	0.47	0.40	0.34

TABLE 1, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESTNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.													
	Standard Gage.	Recording Gage.	5	10	15	20	25	30	45	60	80	100	120	150	180	
1890																
July 25	0.68	0.64	1.40	1.08	0.89	0.80	0.74	0.68	0.54	0.43	0.36	0.31	...	...	...	
July 26	0.96	0.91	3.15	1.83	1.35	1.33	1.26	1.24	1.07	0.87	...	...	...	...	...	
Aug. 6	0.31	0.34	3.28	1.69	...	...	...	...	...	...	...	...	...	...	...	
Aug. 19	0.75	0.72	3.49	2.37	1.71	1.34	1.10	0.94	0.67	0.55	...	...	...	...	...	
1891																
June 2	0.46	0.45	1.84	1.47	1.27	1.07	0.91	0.78	0.57	0.44	...	...	...	...	...	
July 24	0.71	0.75	1.03	0.80	0.72	0.71	0.66	0.61	0.53	0.42	0.38	0.35	...	...	...	
Sept. 5 7	2.83	2.55	3.20	2.66	2.36	2.13	1.89	1.78	1.61	1.39	0.71	...	...	...	...	
Oct. 7 8	2.45	2.12	2.07	1.73	1.34	1.07	1.02	1.08	0.86	0.71	0.67	0.61	0.51	0.47	...	
1892																
June 6	0.32	0.28	2.74	1.78	1.28	0.99	...	...	...	...	...	...	...	...	...	
June 17	1.18	1.07	3.70	2.91	2.29	1.82	1.85	1.72	1.39	1.14	...	...	...	...	...	
June 25	0.43	0.45	3.08	1.65	1.25	1.03	0.91	0.80	0.56	...	...	...	...	...	...	
July 3	0.74	0.66	3.36	1.88	1.30	...	...	...	...	...	...	...	...	...	...	
July 25	0.44	0.34	3.10	2.33	1.81	...	...	...	...	...	...	...	...	...	...	
Aug. 12	2.19	2.17	3.76	2.97	2.79	2.43	2.38	2.42	1.85	1.57	1.23	1.02	0.85	0.69	...	
1893																
July 18	0.73	0.73	1.32	1.26	1.20	1.17	1.15	1.14	0.97	...	...	...	...	...	...	
Aug. 6-7	1.48	0.95	7.45	4.74	3.36	2.61	2.14	...	...	...	...	...	...	...	...	
1894																
July 21	1.44	1.43	4.11	3.90	3.50	3.20	2.63	...	...	...	...	...	...	...	...	
July 25	0.82	0.77	3.96	2.68	1.87	1.43	...	...	...	...	...	...	...	...	...	
Aug. 20	1.40	1.42	3.55	2.96	2.56	2.12	2.01	1.80	1.35	1.07	0.88	0.74	0.64	0.53	0.45	

TABLE I, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (CHESNUT HILL GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Inches of Total Rainfall.		Maximum Average Intensity in Inches per Hour for the Time Stated.													
	Standard Gage.	Recording Gage.														
			5	10	15	20	25	30	45	60	80	100	120	150	180	
<i>1905</i>																
June 12-13	1.60	1.25	2.76	2.54	2.56	2.30	...	...	...	...	...	...	...	...	...	...
July 14	0.82	0.77	2.80	1.65	1.36	1.05	...	...	...	...	...	...	...	...	...	...
Aug. 12	1.06	1.08	3.53	2.94	2.36	2.06	1.67	1.39	1.05	0.97	...	...	...	...	...	...
Sept. 2-4	5.24	4.87	2.08	1.36	1.17	0.97	0.80	0.89	0.73	0.72	0.67	0.59	0.59	0.52	0.45	0.45
<i>1906</i>																
Mar. 4	2.63	2.39	3.17	1.85	1.28	1.03	0.85	0.77	0.66	0.59	0.50	0.49	0.44	0.42	0.40	0.40
May 27-29	3.89	3.34	0.97	0.77	0.70	0.63	0.59	0.58	0.54	0.51	0.50	0.45	0.42	0.37	0.33	0.33
June 30-																
July 1	1.71	1.53	1.08	0.87	0.81	0.90	0.62	0.56	0.54	0.52	0.47	0.47	0.44	0.40	0.35	0.35
Aug. 27	0.72	0.67	2.72	2.14	1.64	1.30	1.06	0.90	0.62	0.50	0.44	0.36	0.32	0.28	0.25	0.25
<i>1907</i>																
June 29-30	1.09	0.98	1.07	0.87	0.84	0.80	0.80	0.77	0.59	0.50	0.50	0.43	0.40	0.34	0.29	0.29
Sept. 2-4	3.34	2.84	2.84	2.27	2.03	2.05	1.84	1.65	1.32	1.07	0.88	0.83	0.74	0.61	0.53	0.53
Sept. 4-5	3.34	2.84	2.55	1.58	1.56	1.35	1.36	1.32	1.23	0.97	0.83	0.71	0.60	...	...	...
Sept. 21	0.23	0.24	1.12	1.09	0.77	0.44	0.33	...	...	...	...	...	...	...	...	...
Sept. 22-24	2.35	2.04	1.65	1.24	1.01	0.96	0.86	0.74	0.60	0.54	0.44	0.41	...	...	...	...
Oct. 8	1.67	1.11	3.24	2.25	1.74	1.44	1.22	1.05	0.76	0.60	...	...	...	...	...	...
Nov. 3	0.95	0.74	1.69	1.39	1.18	1.08	0.95	0.87	0.82	0.64	...	...	...	...	...	...
<i>1908</i>																
Sept. 27	1.09	0.86	2.13	1.37	1.02	0.80	0.70	0.61	0.57	0.50	0.40	0.33	0.29	0.23	...	...
Oct. 26	1.42	1.23	1.79	1.11	0.87	0.70	0.64	0.51	0.40	0.31	0.25	0.26	0.24	0.24	0.23	0.23
<i>1909</i>																
June 13	0.89	0.76	1.40	0.98	0.84	0.70	0.65	0.68	0.62	0.54	0.58	0.49	0.42	...	...	...
Sept. 23	0.91	0.83	2.65	1.89	1.58	1.29	1.16	1.06	0.75	0.56	...	...	...	...	...	...
Nov. 24-26	3.44	2.95	0.70	0.55	0.46	0.45	0.47	0.44	0.45	0.43	0.42	0.42	0.42	0.38	0.38	0.38

[illegible]

TABLE 2.—EXCESSIVE PRECIPITATION AT BOSTON FROM RECORDS OF

Date.	Storm.		Total Precip. Ins.	Excessive Precipitation.		Amt. Before Excess Rate Began.
	Began.	Ended.		Began.	Ended.	
<i>1891</i>						
July 4.....						
<i>1892</i>						
June 25.....						
July 3.....						
Aug. 12.....	12.05a.	1.35a.	1.47			
<i>1893</i>						
May 3-4.....						
Aug. 6.....	6.09p.	6.29p.	1.00			
<i>1894</i>						
July 21.....						
July 25.....						
Aug. 20.....	12.32p.	1.32p.	1.68			
<i>1895</i>						
July 14.....						
Aug. 18.....						
Oct. 12-13.....						
<i>1897</i>						
July 29.....	D. N.	10.05a.	1.48	6.27a.	8.27a.	0.16
Aug. 4.....	4.38p.	5.14p.	0.58	4.50p.	5.10p.	0.04
Aug. 24.....	8.45a.	1.40p.	1.45	12.40p.	1.28p.	0.58
Sept. 20.....	3.37p.	6.25p.	0.70	4.35p.	5.00p.	0.09
<i>1898</i>						
July 4.....	4.00p.	5.03p.	0.48	4.37p.	4.51p.	0.06
Aug. 17.....	4.50p.	7.25p.	1.03	5.00p.	5.35p.	T
Sept. 7.....	5.00p.	7.30p.	0.55	6.50p.	7.00p.	0.03
<i>1899</i>						
Aug. 22.....	6.05a.	7.30p.	1.38	6.09p.	7.20p.	T
Sept. 20.....	4.00a.	12.30p.	2.82	7.20a.	9.20a.	0.67
<i>1900</i>						
July 25.....	5.30p.	8.15p.	0.50	5.32p.	5.42p.	T
Aug. 16.....	3.10a.	12.55p.	1.04	12.10p.	12.30p.	0.50
<i>1901</i>						
Aug. 24-25.....	6.35p.	D. N.	2.08	11.20p.	12.25a.	0.21
<i>1902</i>						
Aug. 11.....	1.00p.	3.00p.	0.85	1.14p.	1.45p.	T
<i>1903</i>						
June 20-21.....	5.30p.	11.50p.	2.51	3.25p.	3.50p.	1.29
Oct. 17-18.....	1.05p.	6.50a.	2.58	2.58p.	3.18p.	0.09
<i>1904</i>						
Aug. 2.....	5.20a.	8.20a.	0.54	5.23a.	5.38a.	T
Sept. 14-15.....	9.40p.	9.30a.	3.48	6.05a.	7.50a.	1.53
<i>1905</i>						
June 19.....	3.15a.	11.10a.	0.93	8.05a.	8.30a.	0.28
June 26.....	2.44p.	3.15p.	0.78	2.49p.	2.59p.	T
Aug. 12.....	11.45a.	12.50p.	1.26	11.47a.	12.45p.	T

* See annual reports of chief of Weather Bureau, and Monthly Weather Review.

MAXIMUM RATES OF PRECIPITATION AT BOSTON. 61

U. S. WEATHER BUREAU, 1891-1916, INCLUSIVE.*

Cumulative Precipitation (Ins.) in Successive Periods during Excessive Rate.

	5	10	15	20	25	30	35	40	45	50	60	80	100	120	150
<i>1891</i>															
July 4	.40†	.47†	...	...	...	...	...	...	...	...	0.54†	...	...	...	...
<i>1892</i>															
June 25	.30†	.35†	...	...	...	...	...	...	...	...	0.45†	...	...	...	...
July 3	.25†	.28†	...	...	...	...	...	...	...	...	0.42†	...	...	...	...
Aug. 12	.05	.40	.85	0.88	0.90	1.15	1.35	1.44	1.47	...	...	...	...	...	...
<i>1893</i>															
May 3-4	Out of order														
Aug. 6	.03	.21	.53	0.88	1.00	...	...	...	...	...	...	...	...	...	...
<i>1894</i>															
July 21	.35†	.50†	...	...	...	...	...	...	...	...	0.73†	...	...	...	...
July 25	.29†	.37†	...	...	...	...	...	...	...	...	0.39†	...	...	...	...
Aug. 20	.05	.12	.23	0.33	0.86	1.19	1.43	1.60	1.63	1.66	1.68	...	...	...	...
<i>1895</i>															
July 14	.27†	.33†	...	...	...	...	...	...	...	...	0.33†	...	...	...	...
Aug. 18	.29†	.38†	...	...	...	...	...	...	...	...	0.93†	...	...	...	...
Oct. 12-13	.10†	.19†	...	...	...	...	...	...	...	...	0.70†	...	...	...	...
<i>1897</i>															
July 29	.30	.39	.45	0.49	0.52	0.62	0.68	0.77	0.78	0.99	1.04	1.12	1.17	1.22	...
Aug. 4	.06	.23	.46	0.53	...	...	...	...	...	...	...	...	...	...	...
Aug. 24	.03	.07	.24	0.42	0.53	0.57	0.61	0.71	0.82	0.85	...	...	...	...	...
Sept. 20	.05	.12	.24	0.41	0.47	...	...	...	...	...	...	...	...	...	...
<i>1898</i>															
July 4	.04	.24	.40	0.42	...	...	...	...	...	...	...	...	...	...	...
Aug. 17	.05	.22	.26	0.29	0.63	0.89	0.93	...	...	...	...	...	...	...	...
Sept. 7	.20	.36	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>1899</i>															
Aug. 22	.22	.43	.85	1.06	1.11	1.13	1.15	1.16	1.18	1.21	1.24	1.37	...	...	...
Sept. 20	.07	.15	.23	0.30	0.35	0.39	0.48	0.57	0.61	0.65	0.70	0.94	1.19	1.63	...
<i>1900</i>															
July 25	.30	.35	.36	...	...	...	...	...	...	...	...	...	...	...	...
Aug. 16	.15	.35	.51	0.54	...	...	...	...	...	...	...	...	...	...	...
<i>1901</i>															
Aug. 24-25	.07	.13	.26	0.35	0.53	0.72	0.89	1.24	1.33	1.43	1.76	1.90	...	...	...
<i>1902</i>															
Aug. 11	.10	.26	.38	0.50	0.63	0.70	0.71	...	...	...	...	...	...	...	...
<i>1903</i>															
June 20-21	.08	.22	.38	0.46	0.51	0.54	0.56	...	...	...	...	...	...	...	...
Oct. 17-18	.23	.41	.43	0.48	...	...	...	...	...	...	...	...	...	...	...
<i>1904</i>															
Aug. 2	.14	.36	.38	...	...	...	...	...	...	...	...	...	...	...	...
Sept. 14-15	.07	.08	.17	0.23	0.30	0.41	0.44	0.49	0.59	0.74	0.92	1.30	1.59	1.73	...
<i>1905</i>															
June 19	.18	.31	.39	0.47	0.52	...	...	...	...	...	...	...	...	...	...
June 26	.39	.72	.75	...	...	...	...	...	...	...	...	...	...	...	...
Aug. 12	.06	.16	.27	0.56	0.77	0.78	0.83	0.84	0.94	1.05	1.26	...	...	...	...

† Maximum for period of this length.

TABLE 2, *Continued.* — EXCESSIVE PRECIPITATION AT BOSTON FROM RECORDS OF

Date.	Storm.		Total Precip. Ins.	Excessive Precipitation.		Amt. before Excess Rate Began.
	Began.	Ended.		Began.	Ended.	
1906						
July 10.....	3.37p.	5.50p.	1.12	3.47p.	4.22p.	T
July 30.....	12.10a.	8.15a.	1.36	2.18a.	3.32a.	0.09
Oct. 9.....	8.18p.	D. N.	1.96	9.02p.	10.02p.	0.05
1907						
Sept. 5.....	8.45a.	3.10p.	1.03	1.25p.	2.11p.	0.27
Oct. 8.....	D. N.	1.45p.	1.14	10.33a.	10.48a.	0.60
1908						
Aug. 7.....	1.38p.	4.45p.	1.73	1.48p.	2.33p.	T
1910						
June 12.....	12.30a.	7.45a.	0.89	2.23a.	2.47a.	0.15
July 25.....	4.45p.	5.40p.	0.33	5.06p.	5.15p.	T
1911						
June 13.....	12.40p.	5.15p.	1.09	3.40p.	4.37p.	0.13
July 28.....	2.45a.	6.30p.	3.49	11.10a.	12.53p.	1.08
Sept. 25.....	5.40p.	7.55p.	1.05	5.50p.	6.25p.	T
1912						
July 18.....	3.15p.	7.00p.	1.70	4.18p.	5.22p.	0.08
1913						
July 30.....	1.26p.	2.03p.	0.91	1.28p.	1.53p.	T
Aug. 27.....	12.57p.	1.50p.	0.78	1.07p.	1.27p.	T
1915						
July 1.....	2.00a.	7.30a.	3.37	3.53a.	6.43a.	0.35
Aug. 4-5.....	10.30a.	6.00p.	2.28	2.40p.†	4.00p.†	0.65
1916						
July 3.....	3.55p.	6.15p.	1.71	4.34p.	5.05p.	0.17

* See annual reports of chief of Weather Bureau, and Monthly Weather Review.

† August 4.

average will come during two such periods, but both may come within one such period without affecting the average frequency. Such a curve may also be exceeded by several storms, because the intensity curve is based on and covers many periods and several storms. For example, the 5-minute period of the curve may be based on one storm, the 10- to 30-minute period on another and the 30- to 120-minute period upon a third.

In the same way the curve may be exceeded by one storm for a 5-minute period, by another for a 10- to 30-minute period, and by a third for a 30- to 120-minute period. Such a curve would have been exceeded by three storms, but no point of the curve would have been exceeded by more than one storm.

MAXIMUM RATES OF PRECIPITATION AT BOSTON. 63

U. S. WEATHER BUREAU, 1891-1916, INCLUSIVE.*

Cumulative Precipitation (Ins.) in Successive Periods during Excessive Rate.

	5	10	15	20	25	30	35	40	45	50	60	80	100	120	150
<i>1906</i>															
July 10	.07	.20	.33	0.61	0.75	0.77	0.96	...	...	...	...	...	...	...	...
July 30	.05	.10	.16	0.24	0.28	0.33	0.49	0.59	0.67	...	...	...	...	...	...
Oct. 9	.11	.24	.40	0.56	0.67	0.86	0.95	1.10	1.26	1.45	1.58	...	...	...	...
<i>1907</i>															
Sept. 5	.05	.17	.25	0.33	0.42	0.52	0.61	0.66	0.72	...	...	...	...	...	...
Oct. 8	.17	.31	.35	...	...	...	...	...	...	...	...	...	...	...	...
<i>1908</i>															
Aug. 7	.07	.11	.23	0.57	1.13	1.30	1.52	1.54	1.62	...	...	...	...	...	...
<i>1910</i>															
June 12	.09	.32	.40	0.47	0.52	...	...	...	...	...	...	...	...	...	...
July 25	.24	.30	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>1911</i>															
June 13	.12	.31	.37	0.44	0.55	0.63	0.68	0.70	0.72	0.75	0.88	...	...	...	...
July 28	.06	.14	.19	0.22	0.20	0.30	0.37	0.41	0.48	0.53	0.70	1.16	1.33	1.55	...
Sept. 25	.20	.41	.62	0.74	0.92	1.01	...	...	...	...	...	...	...	...	...
<i>1912</i>															
July 18	.11	.21	.37	0.48	0.59	0.77	0.95	1.11	1.30	1.36	1.52	1.59	...	...	...
<i>1913</i>															
July 30	.13	.42	.56	0.76	0.91	...	...	...	...	...	...	...	...	...	...
Aug. 27	.31	.42	.67	0.77	...	...	...	...	...	...	...	...	...	...	...
<i>1915</i>															
July 1	.09	.13	.19	0.26	0.35	0.46	0.59	0.70	0.80	1.00	1.20	1.54	1.89	2.25	2.81
Aug. 4-5	.10	.16	.24	0.32	0.40	0.45	0.51	0.60	0.69	0.77	0.90	1.17	...	...	...
<i>1916</i>															
July 3	.28	.50	.72	1.13	1.18	1.33	1.34	...	...	...	...	...	...	...	...

Comparison of Chestnut Hill and Weather Bureau Frequency Curves. — It has already been noted that the Weather Bureau recording gage was established in 1891, or twelve years later than the Chestnut Hill Reservoir gage. In order to compare the rainfall at the two stations, the records covering the period from 1891 to 1916 have been worked up separately for each station. The frequencies corresponding to various intensities have been plotted and smooth curves constructed for each of the stations. These frequency curves are reproduced on Fig. 3, and coördinates taken from the curves are tabulated in Table 4.

A study of Fig. 3 and Table 4 shows that there are material differences between the several curves for the two stations. The 26-year frequency curve for Chestnut Hill station is continu-

1899	4.92	3.78	3.36	3.18	2.67	2.26	1.98	1.74	1.57	1.45	1.24	1.03	.....
Aug. 22.....	1.80	1.38	.....	1.32	.....	.....	.....	1.04	.....	.....	0.98	.....	0.82
1900	3.60	2.10	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 25.....	2.40	2.16	2.04	1.62	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 16.....	4.20	3.12	2.84	2.67	2.35	2.16	.....	2.19	2.00	1.96	1.76	1.43	.....
1901	1.92	1.68	1.60	1.59	1.51	1.40	1.22	.....	.....	.....	.....	.....	.....
Aug. 24-25.....	1.92	1.80	1.52	1.38	1.23	1.08	0.96	.....	.....	.....	.....	.....	.....
1902	2.76	2.46	1.72	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 11.....	2.64	2.16	1.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	2.28	2.24	2.24	2.13	1.94	1.72	1.53	1.50	1.46	1.38	1.30	1.20	1.04
June 20-21.....	2.16	1.86	1.56	1.41	1.25	.....	.....	.....	.....	.....	.....	.....	.....
1904	4.68	4.32	3.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 2.....	3.48	3.00	2.44	2.13	1.85	1.56	1.42	1.34	1.32	1.26	1.26	.....	.....
1905	3.36	2.52	2.20	2.04	1.82	1.78	1.65	.....	.....	.....	.....	.....	.....
July 10.....	1.92	1.56	1.36	1.17	1.04	1.02	0.98	0.93	0.89	.....	.....	.....	.....
1906	2.28	2.10	2.00	.....	1.88	.....	.....	1.82	1.78	1.74	1.58	.....	.....
Oct. 9.....	1.44	1.20	.....	.....	1.13	1.12	1.05	1.01	0.96	.....	.....	.....	.....
1907	2.04	1.86	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sept. 5.....	6.72	5.40	4.28	3.87	3.38	2.90	2.60	2.30	2.16	.....	.....	.....	.....
1908	2.76	1.92	1.60	1.41	1.25	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 7.....	2.88	1.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 12.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 25.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

† 0.15 for 38 hours.

† 0.54 for 4 hours.

* 0.48 for 4 hours.

TABLE 3, *Continued.* — MAXIMUM INTENSITIES OF PRECIPITATION AT BOSTON (WEATHER BUREAU GAGE) FOR VARIOUS PERIODS DURING EXCESSIVE RATE.

Date.	Maximum Average Intensity in Inches per Hour for the Time Stated in Minutes.													
	5	10	15	20	25	30	35	40	45	50	60	80	100	120
<i>1911</i>														
June 13.....	2.28	1.86	1.48	1.32	1.32	1.26	1.17	1.05	0.96	0.90	0.88	....	....	....
July 28.....	....	....	....	1.38	....	1.26	1.17	1.13	1.05	1.03	0.94	0.87	0.80	0.78
Sept. 25.....	2.52	2.52	2.48	2.22	2.21	2.02	....	....	....	....	....	....	....	....
<i>1912</i>														
July 18.....	2.16	2.16	....	2.13	1.97	1.88	1.88	1.79	1.73	1.63	1.52	1.20	....	....
<i>1913</i>														
July 30.....	3.48	2.58	2.52	2.34	2.18	....	....	....	....	....	....	....	....	....
Aug. 27.....	3.72	2.52	2.68	2.31	....	....	....	....	....	....	....	....	....	....
<i>1915</i>														
July 18.....	2.40	1.80	1.64	1.62	1.56	1.52	1.46	1.41	1.34	1.28	1.21	1.21	1.21	1.18
Aug. 4-5.....	1.20	0.96	0.96	0.96	0.96	0.92	0.92	0.92	0.92	0.92	0.90	0.88	....	....
<i>1916</i>														
July 3.....	4.92	3.78	3.40	3.39	2.84	2.66	2.30	....	....	....	....	....	....	....

§ 1.60 for 170 minutes.

ously higher than that for the Weather Bureau station, the differences being much more marked for the shorter than for the longer periods. Likewise the 20-year frequency curve for Chestnut Hill station is continuously higher than that for the Weather Bureau station. The 15-year curves cross twice, the Chestnut Hill station curve being higher for the 5-minute period and for the 60-, 80-, 100- and 120-minute periods, and lower for the 10-,

TABLE 4. — COÖRDINATES OF PRECIPITATION CURVES OF VARIOUS FREQUENCIES, ACCORDING TO THE CHESTNUT HILL AND WEATHER BUREAU RECORDS, BOSTON, MASS., TWENTY-SIX YEARS, 1891-1916, INCLUSIVE.

Duration. (Min.)	Maximum — 26 Years.		Frequency — 20 Years.		Frequency — 15 Years.	
	Intensity at		Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	7.50	6.70	7.40	6.70	7.40	6.70
10	6.43	5.46	5.70	5.38	5.13	5.15
15	5.50	4.47	4.63	4.41	3.98	4.30
20	4.68	3.92	3.98	3.85	3.38	3.77
30	3.58	3.02	3.15	2.98	2.77	2.93
45	2.55	2.30	2.32	2.20	2.15	2.17
60	2.04	1.75	1.93	1.72	1.80	1.69
80	1.70	1.40	1.58	1.35	1.48	1.30
100	1.45	1.22	1.32	1.13	1.19	1.07
120	1.28	1.12	1.12	0.99	0.95	0.86

Duration. (Min.)	Frequency — 10 Years.		Frequency — 5 Years.	
	Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	5.35	6.23	4.15	4.90
10	4.22	4.95	3.45	4.12
15	3.52	4.02	2.87	3.43
20	3.02	3.47	2.48	2.85
30	2.49	2.75	1.98	2.27
45	2.01	2.06	1.57	1.79
60	1.70	1.62	1.33	1.44
80	1.35	1.22	1.09	1.04
100	1.05	0.95	0.88	...
120	0.84	0.74	0.73	...

TABLE 4, *Continued.*

Duration. (Min.)	Frequency — 3 Years.		Frequency 2 Years.	
	Intensity at		Intensity at	
	Chestnut Hill.	Weather Bureau.	Chestnut Hill.	Weather Bureau.
5	3.80	4.24	3.68	3.58
10	3.03	3.38	2.88	2.83
15	2.54	2.75	2.40	2.31
20	2.20	2.34	2.05	1.95
30	1.76	1.85	1.60	1.57
45	1.33	1.43	1.24	1.18
60	1.07	1.15	1.01	0.88
80	0.88	0.83	0.82	...
100	0.75	...	0.67	...
120	0.64	...	0.57	...

15-, 20-, 30- and 45-minute periods. The 10-year frequency curve for Chestnut Hill station is lower for periods of from 5 to 45 minutes and higher for periods of from 60 to 120 minutes. The 5-year curve for the Weather Bureau station is continuously the higher until the 80-minute period is reached. The Weather Bureau curve is continuously the higher for the 3-year frequency, and for the 2-year frequency the Chestnut Hill curve is the higher.

On the whole, the curves of the two stations are as nearly coincident as can be expected, as there are several causes for differences. Among these, perhaps the most important are the relative elevations of the gages above the ground, that at Chestnut Hill being 25 ft. and that of the Weather Bureau 150 ft. above the ground. At Chestnut Hill the recording gage is checked with a standard gage 1 ft. above the ground. This is not done at the Weather Bureau. The corrections at Chestnut Hill are substantial in amount although they are applied uniformly throughout the storm, while in fact they probably should vary more or less proportionately to the rates of precipitation. It is probable that these errors and corrections apply in greater measure to the periods of high intensity than to those of moderate intensity; that is, to very intense storms and to the periods

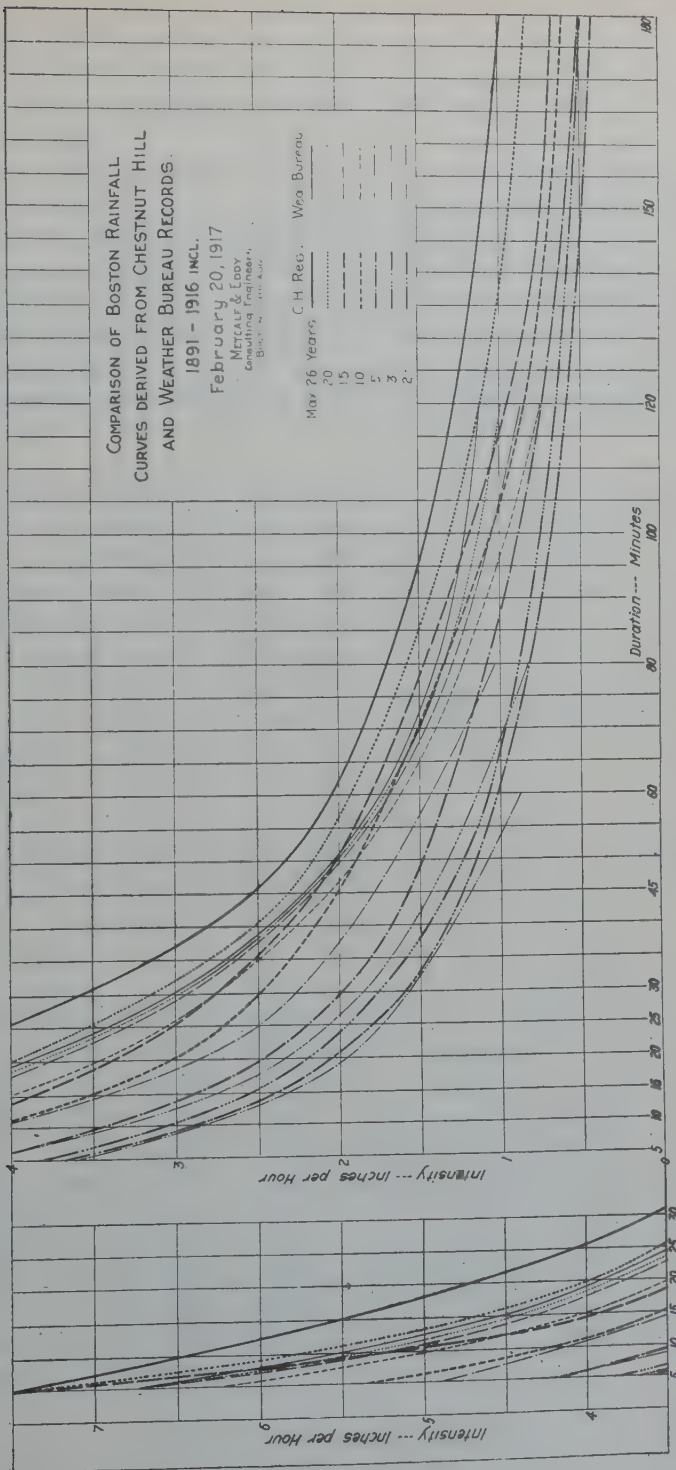


FIG 3.

of high intensity in all storms or the short periods, as from five to thirty minutes.

The maximum, 20-year and 15-year frequency curves are dependent upon a very few storms, and therefore the curves for one station may be greatly influenced by the fact that one gage was in a storm center, whereas the other gage may have been at some distance from the storm center and therefore in a less intense precipitation. In fact, the gages are so far apart that severe storms frequently pass over one without affecting the other.

The periods of precipitation were selected from the Chestnut Hill charts in a manner to assure the inclusion of the maximum total precipitation for the time under consideration. The Weather Bureau records, however, give the quantity for each even five minutes during the downpour. This difference in treatment of the recorded precipitation might give slightly different results even if the original charts were identical.

Chestnut Hill Records for Thirty-eight Years, 1879-1916, Inclusive. — Frequency curves for the entire period covered by

TABLE 5. — COÖRDINATES OF PRECIPITATION CURVES OF VARIOUS FREQUENCIES, ACCORDING TO THE CHESTNUT HILL RECORDS, THIRTY-EIGHT YEARS, 1879-1916, INCLUSIVE.

Duration. (Min.)	Intensity in Inches per Hour.						
	Maximum 38 Years.	Frequency.					
		20 Years.	15 Years.	10 Years.	5 Years.	3 Years.	2 Years.
5	9.10	7.50	7.40	5.80	4.56	3.97	3.71
10	6.70	5.17	4.85	4.57	3.52	3.03	2.81
15	5.40	4.17	3.82	3.53	2.84	2.52	2.27
20	4.65	3.59	3.31	3.00	2.42	2.17	1.97
30	3.60	2.75	2.65	2.48	1.87	1.75	1.55
45	2.58	2.08	2.00	1.94	1.58	1.37	1.24
60	2.06	1.79	1.65	1.60	1.35	1.15	1.05
80	1.70	1.48	1.35	1.30	1.11	0.92	0.85
100	1.45	1.29	1.18	1.06	0.89	0.76	0.70
120	1.29	1.20	1.02	0.88	0.75	0.66	0.61
150	1.13	1.10	0.87	0.72	0.62	0.57	0.51
180	1.01	1.01	0.79	0.65	0.54	0.50	0.45

the Chestnut Hill records, 1879-1916, inclusive, have been prepared. These curves are shown in Figs. 4 and 5, and the coördinates of these curves are compiled in Table 5.

Mathematical curves have been drawn which coincide as nearly as practicable with the 20-year, 15-year and 10-year frequency curves. The equations of these curves together with their coördinates and those of the original frequency curves are given in Table 6, from which the two sets of curves can be compared.

TABLE 6. — COMPARISON OF MATHEMATICAL CURVES WITH CHESTNUT HILL FREQUENCY CURVES (1879-1916).

Duration. (Min.)	$i = \frac{21.0}{t^{0.6}}$	20-Year Frequency Curve.	$i = \frac{20.4}{t^{0.61}}$	15-Year Frequency Curve.	$i = \frac{125}{t+20}$	10-Year Frequency Curve.
5	8.00	7.50	7.64	7.40	5.00	5.80
10	5.28	5.17	4.95	4.85	4.17	4.57
15	4.13	4.17	3.91	3.82	3.57	3.53
20	3.48	3.59	3.28	3.31	3.12	3.00
30	2.73	2.75	2.56	2.65	2.50	2.48
45	2.14	2.08	2.00	2.00	1.92	1.94
60	1.80	1.79	1.68	1.65	1.56	1.60
80	1.52	1.48	1.41	1.35	1.25	1.30
100	1.32	1.29	1.23	1.18	1.04	1.06
120	1.19	1.20	1.10	1.02	0.89	0.88
150	1.04	1.10	0.96	0.87	0.74	0.72
180	0.93	1.01	0.86	0.79	0.63	0.65

Thirty-Eight Year Frequency Curve. — The 38-year frequency curve, which is in fact the maximum intensity curve, is determined by the intensities of precipitation reached in the three storms shown in Table 7.

The storm of July 18, 1884, was of determining importance only for the 5-minute period. The intensity during this period was the greatest of which there is record at Chestnut Hill. The intensity for 10 minutes was lower than that of the 20-year curve and practically identical with that of the 15-year curve. It was not significant therefore in the establishment of the maximum curve. The intensity for the 15-minute period was lower than that of the 10-year mathematical curve.

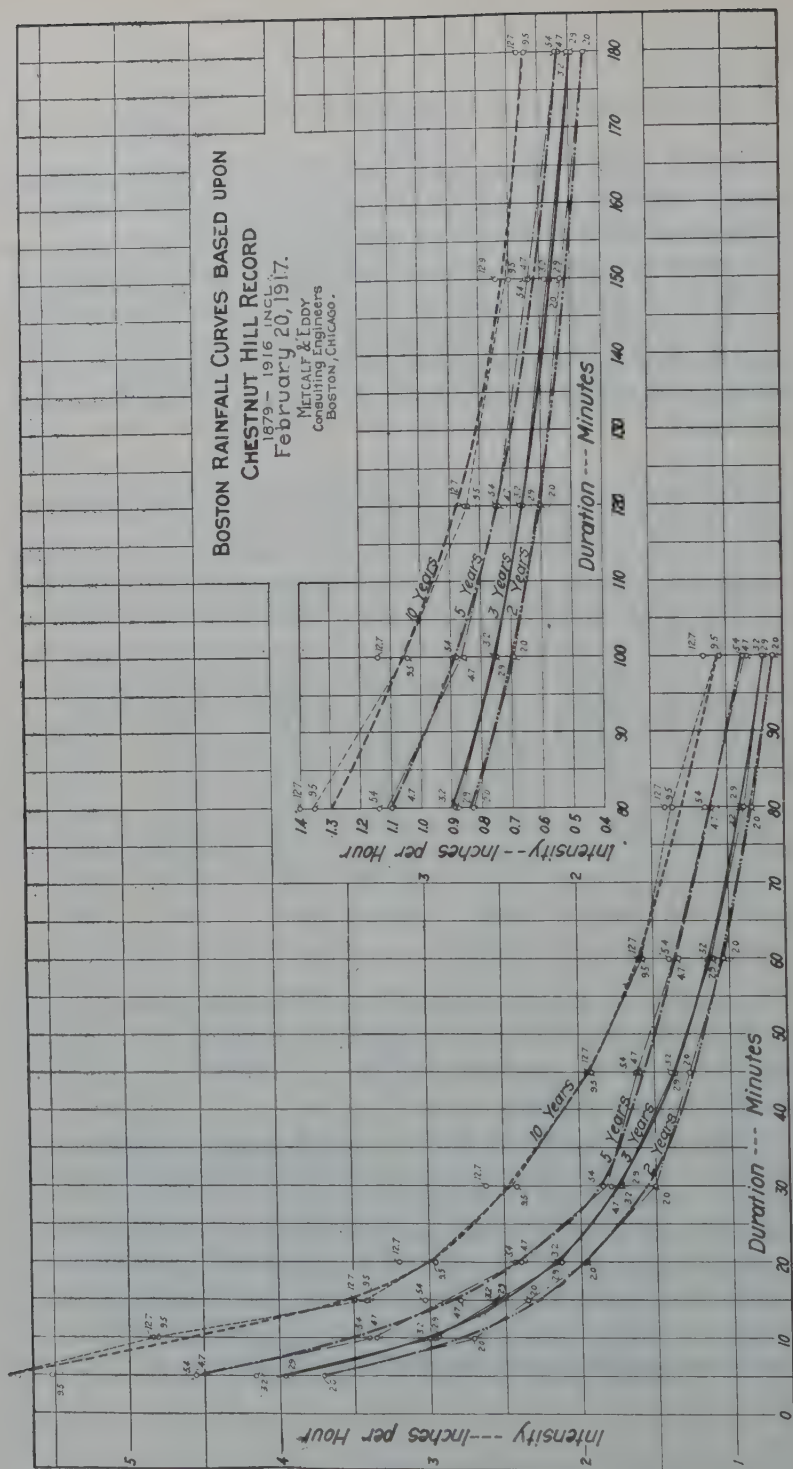


FIG. 4.

**BOSTON RAINFALL CURVES BASED UPON
CHESTNUT HILL RECORD
1879 - 1916 INCL.
February 20, 1917.**

NETCALF & EDDY
ENGINEERS
BOSTON, CHICAGO.

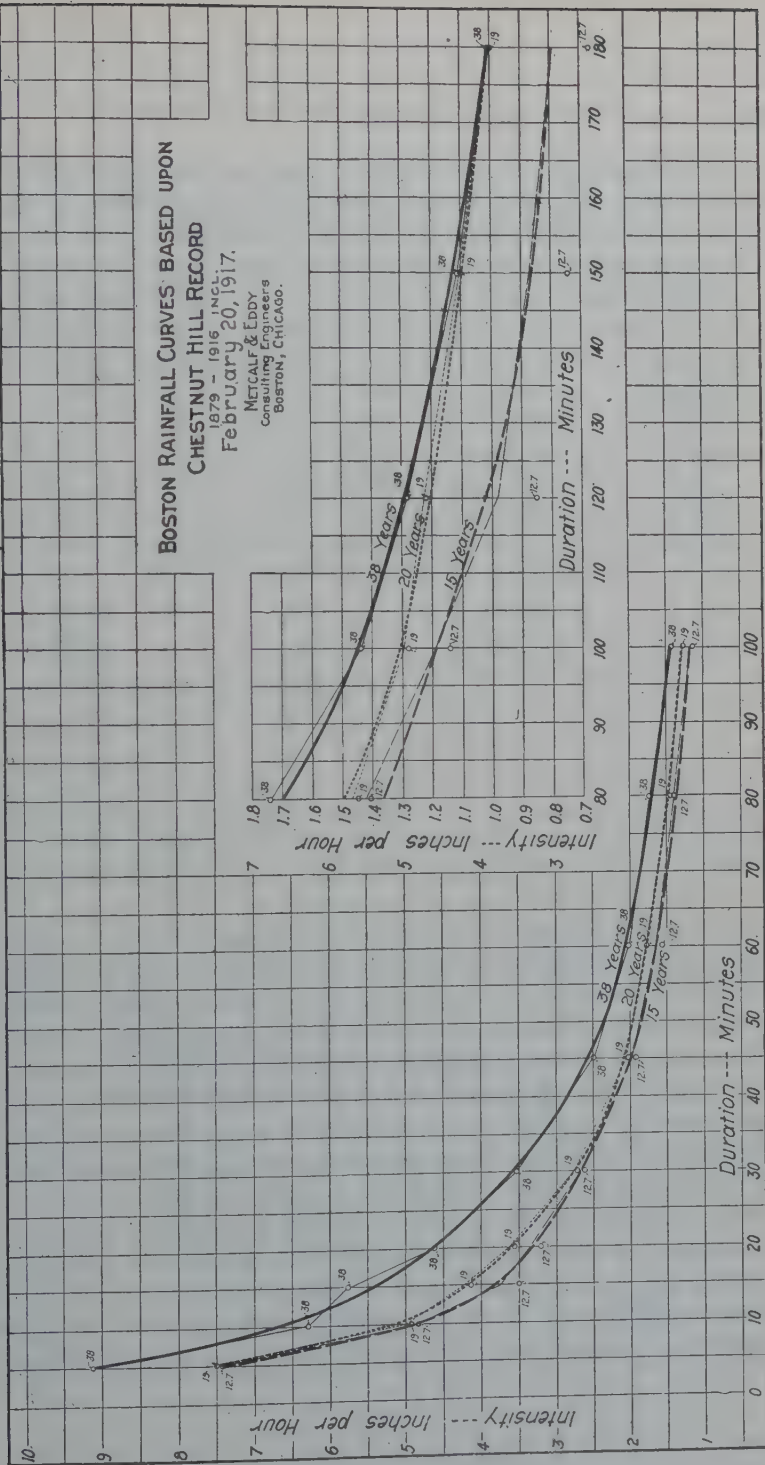


FIG. 5.

The storm of August 22, 1899, appears to have been the most severe, from the point of view of city drainage problems, of any storm covered by the records. The intensities of this storm govern the maximum curve, for periods of from 10 to 80 minutes.

The storm of June 30 to July 3, 1915, had intensities for periods of from 100 to 180 minutes, which were of controlling importance. The intensities for shorter periods were not significant.

TABLE 7. — RATE OF PRECIPITATION OF EXTREME STORMS, INCHES PER HOUR.

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30 — July 3, 1915.
5	9.12	7.42	2.37
10	4.93	6.30	2.09
15	3.41	5.77	1.90
20	...	4.62	1.81
30	...	3.53	1.74
45	...	2.50	1.62
60	...	2.02	1.57
80	...	1.74	1.45
100	...	...	1.43
120	...	...	1.28
150	...	...	1.11
180	...	...	1.01

From the foregoing discussion it will be seen that each of the three severe storms determined the location of a portion of the maximum intensity curve, but that no two storms supported the same part of the curve. It is clear, therefore, that any sewer designed on the basis of this curve would be utilized to its capacity only once in thirty-eight years and by that storm which furnished the maximum precipitation for the period corresponding to the time of concentration of the particular sewer under consideration. Furthermore, the sewer would not be called upon to provide for the maximum run-off until its drainage area should have been developed to the extent assumed for the end of the period for which the sewer is designed, nor under climatic or other conditions unfavorable to a maximum rate of run-off. To build sewers of capacity sufficient to accommodate the run-off from

MAXIMUM RATES OF PRECIPITATION AT BOSTON. 75

TABLE 8. — RATES OF PRECIPITATION OF STORMS WHICH EXCEEDED THE CURVE, $i = \frac{21.0}{t^{0.6}}$ (APPROX. 20-YEAR FREQUENCY CURVE), FROM 1879 TO 1916.

(Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	July 20, 1880.
5	9.12	7.42	2.37	5.52
10	4.93	6.30	2.09	4.83
15	3.41	5.77	1.90	4.14
20	...	4.62	1.81	3.56
30	...	3.53	1.74	2.72
45	...	2.50	1.62	1.94
60	...	2.02	1.57	1.50
80	...	1.74	1.45	1.23
100	...	...	1.43	1.04
120	...	...	1.28	0.83
150	...	...	1.11	...
180	...	...	1.01	...

TABLE 9. — RATES OF PRECIPITATION OF STORMS WHICH EXCEEDED THE CURVE, $i = \frac{20.4}{t^{0.61}}$ (APPROX. 15-YEAR FREQUENCY CURVE), FROM 1879 TO 1916.

(Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	July 20, 1880.	August 25, 1901.	August 21, 1888.	September 25, 1911.
5	9.12	7.42	2.37	5.52	4.56	2.80	4.24
10	4.93	6.30	2.09	4.83	3.54	2.54	3.40
15	3.41	5.77	1.90	4.14	3.42	2.55	3.03
20	...	4.62	1.81	3.56	2.96	2.39	2.79
30	...	3.53	1.74	2.72	2.30	1.96	2.62
45	...	2.50	1.62	1.94	2.03	1.72	1.92
60	...	2.02	1.57	1.50	1.78	1.58	...
80	...	1.74	1.45	1.23	1.41	1.36	...
100	...	...	1.43	1.04	...	1.28	...
120	...	...	1.28	0.83	...	1.22	...
150	...	...	1.11	...	...	1.10	...
180	...	...	1.01	...	...	1.00	...

such storms under conditions favorable to maximum run-off and of the ultimate development would involve heavy expense justifiable only under very unusual circumstances. In fact, storms such as these may well be classed as acts of Providence, for which a city cannot reasonably be expected to provide.

Twenty-Year Frequency Curve.—The 20-year frequency curve may be represented approximately by the equation $i = \frac{21.0}{t^{0.6}}$. This form of equation applies equally well to both short and long periods of precipitation. It is not quite as easy of application as some other types of formulas, because it requires the use of logarithms. The intensities of precipitation for the several periods of time indicated by this curve are given in Table 6.

The rates of precipitation of three storms which exceeded this curve, and of a fourth storm which was practically coincident with it, for a short period of time, are given in Table 8. The intensities enclosed within the rectangular areas are those which exceeded the intensities indicated by the mathematical curve. It will be seen that there were but two storms during which the intensities indicated by the mathematical curve were exceeded for the same time lengths, and it may be added that the storm of July 20, 1880, while exceeding this curve, did not exceed the curve as originally plotted from the observed intensities. In other words, the mathematical 20-year frequency curve does not appear to have been materially exceeded but once, for a substantial time length, by the storms recorded at Chestnut Hill. It appears, therefore, that a city would seldom be justified in basing the design of sewers and drains upon this curve, for the reasons given in connection with the maximum 38-year frequency curve.

Fifteen-Year Frequency Curve.—The 15-year frequency curve may be represented approximately by the equation $i = \frac{20.4}{t^{0.61}}$. The intensities of precipitation indicated by this curve for the several time lengths are given in Table 6.

Records of storms which have had intensities in excess of those indicated by this curve are compiled in Table 9. The

intensities enclosed within the rectangular areas are those which exceeded the intensities indicated by the mathematical curve. It will be seen that there were 7 such storms in all. That of September 25, 1911, is of small moment; in fact, its intensity does not exceed the frequency curve as plotted from the recorded data. Practically no portion of the curve was exceeded more than twice in 38 years.

While it may be argued with some justice that this curve indicates intensities higher than those which a city is normally justified in providing for, it will be shown below that the 10-year frequency curve, while exceeded much more frequently, does not indicate intensities sufficiently low to result in the use of materially smaller sizes of sewers. In many cases the differences between the 15-year and 10-year frequency curves would be too small to result in any difference in the size of sewer. It therefore would seem reasonable to adopt for the design of storm-water sewers by the rational method the 15-year frequency curve indicated by the equation, $i = \frac{20.4}{t^{0.61}}$, subject, of course, to any special needs or conditions of the drainage district under consideration.

Ten-Year Frequency Curve. — An equation for the 10-year frequency curve has been developed, differing in form from those computed for the 20-year and 15-year frequency curves. The equation of the 10-year frequency curve is $i = \frac{125}{t+20}$. This form of equation does not apply as well as the exponential form to the very short and very long periods. It is, however, somewhat easier to apply, as it does not require the use of logarithms. The intensities of precipitation indicated by this equation are compiled in Table 6. The records of storms which have exceeded the 10-year mathematical frequency curve have been compiled in Table 10. There have been 12 such storms, although 5 of them exceeded the intensities indicated by the curve for only a single period of time. The storms of August 22, 1899; June 30, 1915; July 20, 1880; August 25, 1901, and August 21, 1888, exceeded the intensities indicated by the curve for substantial lengths of time, and 4 of these 5 storms overlapped. This indi-

cates that a sewer having a concentration period of 60 minutes would have been overcharged by all these storms were its drainage area developed to the extent assumed in the design and were conditions favorable to maximum run-off. It is also important to note that even in those storms in which the mathematical curve intensities were exceeded for only a single period, these periods of excessive precipitation were sufficiently long to have an important effect upon the discharge of many sewers.

The number of times the capacities of sewers designed to serve the storms represented by the 10-year mathematical frequency curve have been exceeded is so large that a city might not be able to justify a policy of basing the design of its sewers upon a curve of so great a frequency.

TABLE 10. — RATES OF PRECIPITATION OF STORMS WHICH EXCEEDED THE CURVE, $i = \frac{125}{t+20}$ (APPROX. 10-YEAR FREQUENCY CURVE), FROM 1879 TO 1916, INCLUSIVE. (Inches per Hour.)

Duration of Period.	July 18, 1884.	August 22, 1899.	June 30, 1915.	August 6, 1893.	July 20, 1880.	August 25, 1901.	August 21, 1888.	July 21, 1894.	September 25, 1911.	September 20, 1899.	August 12, 1892.	August 16, 1879.
5	9.12	7.42	2.37	7.45	5.52	4.56	2.80	4.11	4.24	2.27	3.76	2.96
10	4.93	6.30	2.09	4.74	4.83	3.54	2.54	3.90	3.40	1.89	2.97	2.55
15	3.41	5.77	1.90	3.36	4.14	3.42	2.55	3.50	3.03	1.81	2.79	1.97
20	...	4.62	1.81	2.61	3.56	2.96	2.39	3.20	2.79	1.64	2.43	1.65
30	...	3.53	1.74	2.14	2.72	2.30	1.96	...	2.62	1.39	2.42	1.23
45	...	2.50	1.62	...	1.94	2.03	1.72	...	1.92	1.29	1.85	0.95
60	...	2.02	1.57	...	1.50	1.78	1.58	...	...	1.21	1.57	0.88
80	...	1.74	1.45	...	1.23	1.41	1.36	...	...	1.14	1.23	0.88
100	...	...	1.43	...	1.04	...	1.28	...	...	1.14	1.02	0.88
120	...	...	1.28	...	0.83	...	1.22	...	...	...	...	0.84
150	...	...	1.11	...	...	...	1.10	...	...	...	...	0.74
180	...	...	1.01	...	...	...	1.00	...	...	...	...	0.67

MEMOIRS OF DECEASED MEMBERS.

EDMUND GROVER.*

EDMUND GROVER, son of the late David F. and Ann M. (Lewis) Grover, died at his home in East Walpole, on October 19, 1919, after an illness of several months.

He was born in East Walpole, April 7, 1855, and was educated in the public schools of Walpole and the Massachusetts Institute of Technology, from which he graduated in the class of 1877 with the degree of S.B.

For two years following graduation he was associated with his father in paper making in New Boston, N. H.

After this period he went West and was connected for a number of years with various railroad companies in their civil engineering and construction departments, including the Chicago, Burlington & Quincy Railroad; Chicago and Grand Trunk; Indiana; Atchison, Topeka & Sante Fé; Colorado, and several smaller lines.

In 1891 he returned East, and for a time was in the office of Olmsted, Olmsted and Eliot, landscape architects. He developed considerable taste for the esthetic side of this branch of engineering and opened an office in East Walpole, where he practiced civil engineering and landscape gardening during the rest of his active life.

He was a member of the Massachusetts Forestry Association and the state and local granges.

As a citizen he was deeply interested in the public schools, and for six years was a member of the school committee, and with his intelligent and progressive ideas he advanced the cause of education.

He was a lover of the best in literature, and a deep thinker on all the important subjects of the times, particularly those pertaining to national affairs.

* Memoir prepared by Richard A. Hale and Arthur L. Plimpton.

He was married in 1883 to Isabelle Jondro, of Milford, N. H. They had three children, E. Stanley, who is a civil engineer with the American Steel and Wire Company of Worcester, Mass.; Arnold F., director of manual training in the Walpole public schools, and Shirley I., wife of Frederick V. Bell, of East Walpole.

These three children with his widow survive him.

IRVING SPARROW WOOD.*

IRVING SPARROW WOOD, son of Charles P. and Sarah S. (Robinson) Wood, was born November 27, 1857, in the city of Providence, and died in the same house in which he was born, October 20, 1919.

He came of early New England stock and could trace his ancestry back to the days of Governor Bradford of Massachusetts.

He was married to Margaret E. Reed, October 14, 1903.

Mr. Wood was educated in the public schools and in Mowry & Goff's English and Classical School, from which he graduated in June, 1877.

He began his professional career when he entered the City Engineer's Office of the city of Providence in the fall of 1877. Most of his time was spent in connection with the Providence Water Works and on May 1, 1899, he was appointed assistant engineer in charge of the Water Department, a position which he held until his death.

He joined the American Society of Civil Engineers as junior, March 5, 1890, became an associate, March 7, 1900, and a member, March 6, 1906. He was also a member of the Boston Society of Civil Engineers, the New England Water Works Association and the Providence Engineering Society.

Mr. Wood was unassuming in manners, conscientious and faithful in the discharge of all duties assigned to him, and a loyal and agreeable associate and friend.

* Memoir prepared by William D. Bullock and James A. McKenna.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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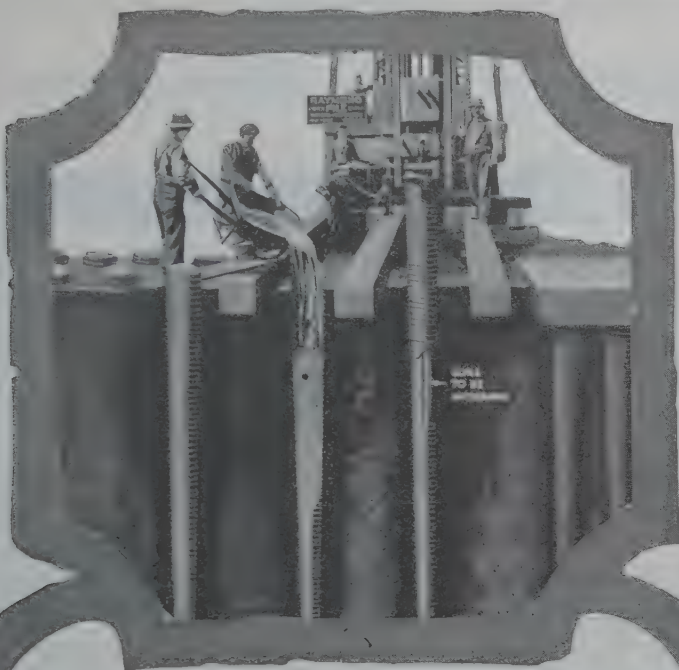
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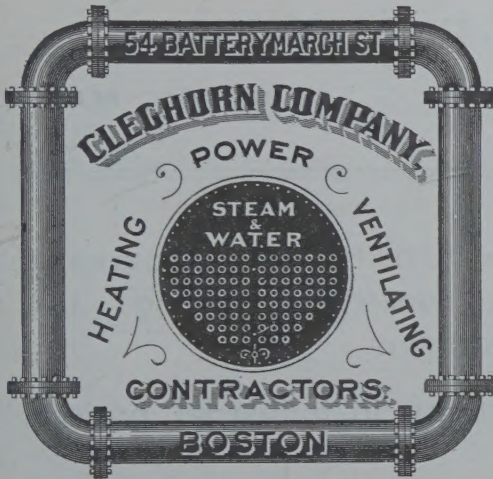
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